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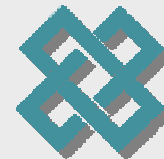
# Second Use of Electric Vehicle Batteries in Stationary Applications

*Presented at*

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Arlington, Virginia  
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*Presented by*

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# Outline

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- **Background**
- **Study tasks**
- **Status**
- **Future work**
- **Acknowledgements**



# Background

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- **Objectives of this Phase I Study**
  - Evaluate feasibility of using “spent” EV/HEV batteries in stationary applications
  - Identify criteria and possible partners for a demonstration project
- **Objectives of future phases**
  - Additional laboratory testing
  - Field trial/demonstration
- **Ultimate goals**
  - Reduce net cost of batteries to EV owner
  - Make advanced batteries available for stationary applications



# Study tasks

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- 1. Gather battery-related information**
- 2. Identify opportunities for stationary battery energy storage**
- 3. Define the issues in reusing spent EV batteries**
- 4. Perform economic analysis for re-use process**
- 5. Identify criteria and partners for possible demonstration**
- 6. Prepare Final Report**



# Status: Battery-related information ---

- **Is there any experience in reusing batteries?**
  - Peer reviewed technical journals
  - Previous studies
  - Personal contacts
- **Findings**
  - There is an active secondary market for used batteries
    - Battery chemistries
      - Lead acid most popular
      - Ni-Cd, Ni-Fe, Ni-MH, Lithium ion (?)
    - Applications
      - Renewable energy systems
      - Ham radio systems
      - Laptop computers (?)



## Status: Battery-related information

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- **ANL/USABC study (1996-1997)**
  - Used Ni-MH batteries from EV test program were evaluated for stationary applications
  - Batteries were tested per USABC test protocol
    - 500 DST cycles to 80% DOD, simulating EV use
  - Evaluated for stationary applications
    - Utility load management
      - Load following
      - Frequency regulation and spinning reserve (UES Cycle)
    - Uninterruptible power systems (UPS)
- **Findings**
  - Performance competitive with new lead acid batteries



## Status: Battery-related information

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- **Battery testing & condition of batteries at EOL**
  - Review EV/HEV battery test manuals
    - USABC, PNGV, MATADOR Task 2
  - Visit battery makers and battery test laboratories
    - ANL, SAFT, Ovonic/ECD
- **Findings**
  - Testing is expensive but necessary
  - Testing after EOL probably at module level
    - Predict future life
    - Sort/match for future reassembly
  - Cycling could give data for predicting future life
    - C/3 capacity and internal impedance
    - 3 to 5 cycles may be enough



# Status: Battery-related information

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- **Auto industry perspectives**
  - Ford, GM, DaimlerChrysler
- **Findings**
  - Batteries will be owned by vehicle buyer
  - In case of problem dealers will...
    - replace EV modules if before expected EOL
    - replace entire HEV battery
  - At EOL dealers will...
    - remove & disassemble EV batteries
    - remove HEV batteries as unit





# Status: Identify opportunities

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- **Looked at three size categories**
  - Utility/industrial
  - Commercial
  - Residential
- **Determined energy storage requirements**
  - Load characteristics
    - Energy
    - Power
    - Duty cycle



# Status: Identify opportunities

APPLICATION	DISCHARGE TIME	PEAK POWER	AVERAGE POWER	ENERGY DELIVERY	FREQUENCY OF USE
Transmission Stabilization	10 sec (up to 5 pulses)	500 MW	N/A	< 500 MWs/ pulse (140 kWh)	1/month
Area Regulation & Spinning Reserve	12 min?	20 MW	$\pm 10$ MW	$\pm 2$ MWh	1/15 min
	15 min full power, 15 min ramp down	20 MW	20 MW	7.5 MWh	1/month
Load Leveling / Energy Arbitrage / Transmission Deferral	5-10 hrs	N/A	10 MW/ 15 MVA	100 MWh	100–200 days/yr (weekdays w/high demand)
Renewables Firming	1 hr or 10 hr	5 MW	1 MW	1–10 MWh	10–20 days/month
Power Reliability & Peak Shaving	3-4 hrs	2 MW	1 MW	3–4 MWh	6/yr 1/day, max.
Light Commercial Load Following	3 hr at average power, overnight at low power	200 kW	25 kW ?	75–100 kWh	1 high DOD cycle/day, many low DOD subcycles
Residential Load Following	3 hr at average power, overnight at low power	10 kW	1 kW	3–4 kWh	1 high DOD cycle/day, many low DOD subcycle
Distributed-Node Telecomm Standby Power	5-10 hrs	5 kW	< 5 kW	25–50 kWh	2/yr



# Status: Identify opportunities

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- **Utility/Industrial applications**

- Utility load leveling/ energy arbitrage (100,000 kWh)
  - Extremely large system
- Renewables firming (1,000–10,000 kWh)
  - Frequent, low rate ( $C/5$ ) discharges
- Area regulation & Spinning reserve (5,000–7,500 kWh)
  - Infrequent, high rate ( $C/2 - C$ ) discharges
- Power reliability/Peak shaving (3,000–4,000 kWh)
  - Power reliability: infrequent, moderate rate ( $\sim C/2$ ) discharges
  - Peak shaving: daily, moderate to high rate ( $C/2 - C$ ) discharges
- Transmission stabilization (140 kWh)
  - 500,000 kW second pulses
  - 5 pulses/10 seconds, once/month



# Status: Identify opportunities

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- **Commercial applications**
  - Peak shaving (3,000–4,000 kWh)
    - Daily, moderate to high rate ( $C/2 - C$ ) discharges
  - Customer-side load following (75–100 kWh)
    - 1 deep discharge and several shallow discharges per day
      - $C/3$  discharge rate typical
  - Distributed node telecommunications
    - Standby power
    - Infrequent, low rate ( $C/5$ ) discharges



# Status: Identify opportunities

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- **Residential applications**
  - Renewable systems (up to 25 kWh for off-grid)
    - Daily, moderately deep (>50% DOD) discharges
  - Self-generation load following (3–4 kWh)
    - 1 deep discharge and several shallow discharges per day
      - C/3 discharge rate typical



# Current activities

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- **Finishing data gathering**
  - Lead-acid batteries
  - Batteries used in heavy hybrids
- **Setting-up framework for economic analysis**
  - Production systems
    - When EVs/EHVs are common
  - Demonstration
    - Near term



# Remaining tasks

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- **Complete economic analysis**
  - Executive-level
- **Recommendations for follow-on phases**
  - Identify need for additional laboratory testing
  - Identify possible demonstration projects
    - Criteria
    - Partners
- **Prepare Final Report**
  - Draft by December 31, 2001
  - Final by January 31, 2001



# Acknowledgements

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